OU3 (OFFSITE) PRELIMINARY RISK ASSESSMENT

REFERENCED FROM

PAST REMEDY REPORT
APRIL, 1991

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

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FINAL
PAST REMEDY REPORT

Operable Unit No. 3 - IHSS 199

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

MAY, 1991

ENVIRONMENTAL RESTORATION PROGRAM

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TABLE 4.2

SUMMARY OF IHSS 199 HISTORICAL PLUTONIUM IN SOIL DATA

Data Source	Range (pCi/g unless otherwise noted)		Average (pCi/g unless otherwise noted)	No. of Data Points	Comments
"Plutonium in Soil Around the Rocky Flats Plant," by P.W. Krey and E.P. Hardy, 1 August 1970 (Appendix D, Document D-1)	0.0007-0.963		0.085	27	1, 2, 3
"Committee Evaluation of Plutonium Levels in Soil Within and Surrounding USAEC Installation at Rocky Flats, Colorado." by J.R. Seed et al., 9 July 1971 (Appendix D, Document D-2)	0.045-139.7		5.0	123	1, 2, 4
"Soil Sampling East of Indiana Avenue," by R.W. Loser and R.L. Tibbals, 29 November 1972 (Appendix D, Document D-3)	2.7-594 mCi/km²		99.3 mCi/km²	14	1, 5
"Results of Special Soil Samples Collected Adjacent to the Rocky Flats Plant Site," by C.T. Illsley, 7 September 1977 (revised 30 November 1979) (Appendix D, Document D-4)	0.01-1.48		0.207	20	1, 2
"Radioactive Soil Contamination (Cesium-137 and Plutonium) in the Environment Near the Rocky Flats Nuclear Weapons Plant," by CDH, September 1977 (Appendix D, Document D-5)	Data contained in this report are included in the 1970-1989 CDH report (Document D-18 below)				
"Plutonium Concentrations in Soil on Lands Adjacent to the Rocky Flats Plant," by C.T. Illsley and M.W. Hume, 16 March 1979 (Appendix D, Document D-7)	0.009-3.42		0.19	160	1, 2
"Disclosure to the City of Broomfield," by Rockwell International, 22 January 1985 (Appendix D, Document D-8)	0.06-7.7		N/A	N/A	1, 2, 6
"Soil Sample Collection and Analysis for Plutonium on Lands Adjacent to Great Western, Reservoir for the City of Broomfield," by C.T. Illsley, 15 January 1987 (Appendix D, Document D-9)	0.04-3.8		1.2	15	1, 2
"Remedial Action Program on Jefferson County Open Space Land in Section 7, T2S, R69W, South of Great Western Reservoir," by C.T. Illsley, 15 October 1987 (Appendix D, Document D-11)	1977	0.06-7.7	1.55	22	1, 7
	1985	0.03-5.6	1.70	24	
"Rocky Flats Surface Soil Survey, 1970-1989," by CDH, February 1990 (Appendix D, Document D-18)	1970	0.01-11.0	1.2	13	1, 2, 4
	1971	0.03-30.1	2.6	13	1, 2, 4
	1972	0.02-25.1	2.1	13	1, 2, 4
	1973	0.03-0.38	0.12	5	1, 2
	1974	0.02-12.7	1.2	13	1, 2, 4
	1975	0.01-4.30	1.1	10	1, 2
	1976	0.02-3.50	0.4	13	1, 2
	1977	0.03-4.20	0.5	13	1, 2
	1978	0.03-0.25	0.09	6	1, 2
	1980	0.01-3.1	0.3	13	1, 2
	1981	0.18-2.2	0.3	12	1, 2
	1986	0.01-1.5	0.2	13	1, 2

COMMENTS:

1   Data do not meet EPA useability criteria for risk assessment (see Appendix A).

2   Values originally expressed in dpm/g; converted to pCi/g using 0.45 multiplier.

3   Included multiple analyses by various laboratories; some data points have multiple values.

4   Some data points are within the present RFP boundary; sample locations are not defined clearly enough to separate these from data points outside the RFP boundary.

5   Document lacks adequate description of sampling and analytical methodology and contains inconsistent definition of sample locations. Because conversion of mCi/km^2 to pCi/g requires detailed knowledge of methodology and properties of the medium sampled, this conversion could not reliably be performed; however, reported values appear to be much higher than those recorded in other sampling programs in this area. Very low confidence in these values.

6   Document presents high, low, and average values from Broomfield remedy acreage sampling between 1977-1985.

7   1977 data do not include Broomfield remedy acreage.

1.0 SOME CONCEPTS OF RISK ASSESSMENT

The principal aim of radiation protection is to reduce the risk of detrimental health effects from radiation exposure. Risk has been defined as the probability that a detrimental health effect will occur in an individual or population. Mortality risk factors are helpful in identifying levels of risk associated with various activities and occupations. Mortality risk factors are listed in Table C.1 for various events. Almost every aspect of modern living exposes people to health risks. This table lists the estimated risk of death to an individual from various human-caused and natural events.

Risk is usually expressed as either absolute risk or relative risk. When applied to radiation exposure an individual's absolute risk of mortality for a specific cause such as cancer is the excess risk from exposure added to his/her background risk of death from cancer. The term lifetime excess cancer risk is used to describe the portion of absolute risk resulting from exposure.

The carcinogenic risk or the cancer risk factor (lifetime excess cancer risk) provides an estimate of the additional incidence of cancer that may be expected in a population exposed to a given contaminant. A risk of 10^{-5}, for example, indicates a probability of one additional case of cancer for every 100,000 people exposed. A risk of 10^{-6} would be 1 case in 1 million people exposed (EPA, 1985). On an individual basis the cancer risk factor describes the additional risk or probability of death from cancer incurred as a result of exposure.

TABLE C.1

PROBABILITY OF DEATH BY VARIOUS CAUSES[a]
(U.S. Population Average for 1978)

Cause	Total Number of Deaths	Individual Risk (Lifetime Probability)[b]
Accidents		
Motor Vehicle	52,411	1.28×10^{-2}
Air Transport	1,880	6.0×10^{-4}
Railway	602	2.0×10^{-4}
Falls	13,690	4.4×10^{-3}
Fire	6,163	2.0×10^{-3}
Drowning	5,784	1.9×10^{-3}
Industrial	5,168	1.7×10^{-4}
Electrocution	984	3.2×10^{-4}
Explosion	562	1.8×10^{-4}
Firearms	1,806	5.8×10^{-4}
Diseases		
Cardiovascular	964,000	3.1×10^{-1}
Malignancies (cancer)	396,720	1.3×10^{-1}
Influenza/Pneumonia	58,230	1.9×10^{-2}
Diabetes	33,800	1.1×10^{-2}
Natural Events		
Lightning	160	5.1×10^{-5}
Tornadoes	118[c]	3.8×10^{-5}
Hurricanes	90[d]	2.9×10^{-5}

[a] Compiled from Transurania documents, EPA 52011-90-015
[b] Based on total U.S. population
[c] 1953-75 average
[d] 1901-71 average

UNDERSTANDING EXPONENTS

Exponential Notation	Decimal Notation	Probability
10^{0}	1.0	1 in 1
10^{-1}	0.1	1 in 10
10^{-2}	0.01	1 in 100
10^{-3}	0.001	1 in 1,000
10^{-4}	0.0001	1 in 10,000
10^{-5}	0.00001	1 in 100,000
10^{-6}	0.000001	1 in 1,000,000
10^{-7}	0.0000001	1 in 10,000,000

The carcinogenic risk posed by exposure to a radionuclide depends upon three factors: dosage (estimated intake), the carcinogenic potency of the chemical (Potency Factor), and the exposure duration.

The carcinogenic potency of a substance depends, in part, upon its route of entry into the body (e.g., ingestion, inhalation, or dermal). Therefore, cancer slope factors (CSFs) are classified according to the route of administration that is applicable to the experimental or epidemiological data from which they were derived. The EPA and other organizations have developed potency factors for the ingestion and/or inhalation routes for some carcinogens.

The length of exposure to a radionuclide must also be taken into account in the calculation of carcinogenic risk since carcinogenic potency factors are based on long-term, low-dose exposure and carcinogenic risk is assumed to be proportional to dose.

Absolute risk takes into account the added risk from exposure and background risk, exposure-specific absolute risk (AR) (such as that from plutonium in soil) can thus be defined as:

AR (cancer death) = Background Risk + Risk from Exposure to Plutonium

Based on the conservative assumptions presented in the generic risk assessment, the added risk from residential home construction in an area of plutonium contamination would result in an increase of 2.2×10^{-7} risk for a plutonium concentration of 1 pCi/g and would result in an increase of 2.2×10^{-6} risk for a concentration of 10 pCi/g, and an increase of 2.2×10^{-5} risk for a concentration of 100 Pci/g.

Theoretical Calculated Generic Risk Assessment for Pu-239*	
Average Soil Concentration	Individual Risk (Lifetime Probability)
1 pCi/g	2.2×10^{-7}
10 pCi/g	2.2×10^{-6}
100 pCi/g	2.2×10^{-5}

*Conservative residential exposure scenario (future use)

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Figure C-1 is a generic "risk curve" for plutonium-239 in soils covering the range of 1 to 100 pCi/g. The hypothetical future use residential exposure scenario is illustrated along with a hypothetical recreational use scenario.

To put this risk in perspective, we will use the natural cancer mortality rate stated by EPA in Table C.1 of 13 percent (about one in eight). An individual's absolute risk of dying from cancer after 70 years from a 30-year exposure to plutonium in soils in a 70-year lifetime would increase from 0.13 to 0.1300002 at 1 pCi/g and 0.130002 for 10 pCi/g based on generic risk assessment assumptions. Table C.2 lists the overall increase in absolute risk resulting from long-term exposure to plutonium in a residential setting.

TABLE C.2

OVERALL INCREASE IN ABSOLUTE RISK
FROM EXPOSURE TO PLUTONIUM IN SOILS

Plutonium Concentration in Soil	Added Risk	Background	Absolute Risk	Increased Risk from Plutonium
1 pCi/g	2.2×10^{-7}	1.3×10^{-1}	0.1300002	0.000015 percent
10 pCi/g	2.2×10^{-6}	1.3×10^{-1}	0.130002	0.00015 percent
100 pCi/g	2.2×10^{-5}	1.3×10^{-1}	0.13002	0.0015 percent

Conservative Residential/Recreational, Multi-Pathway Model

Excess Cancer Risk (y-axis): 1.0×10^{-5}, 1.0×10^{-6}, 1.0×10^{-7}

Pu-239, pCi/gram (x-axis): 1, 10, 100

□ Residential   ⊕ Recreational

Risk Calculations based on values taken from
EPA Exposure Factors Handbook, EPA/600/8-889/043, May 1989.
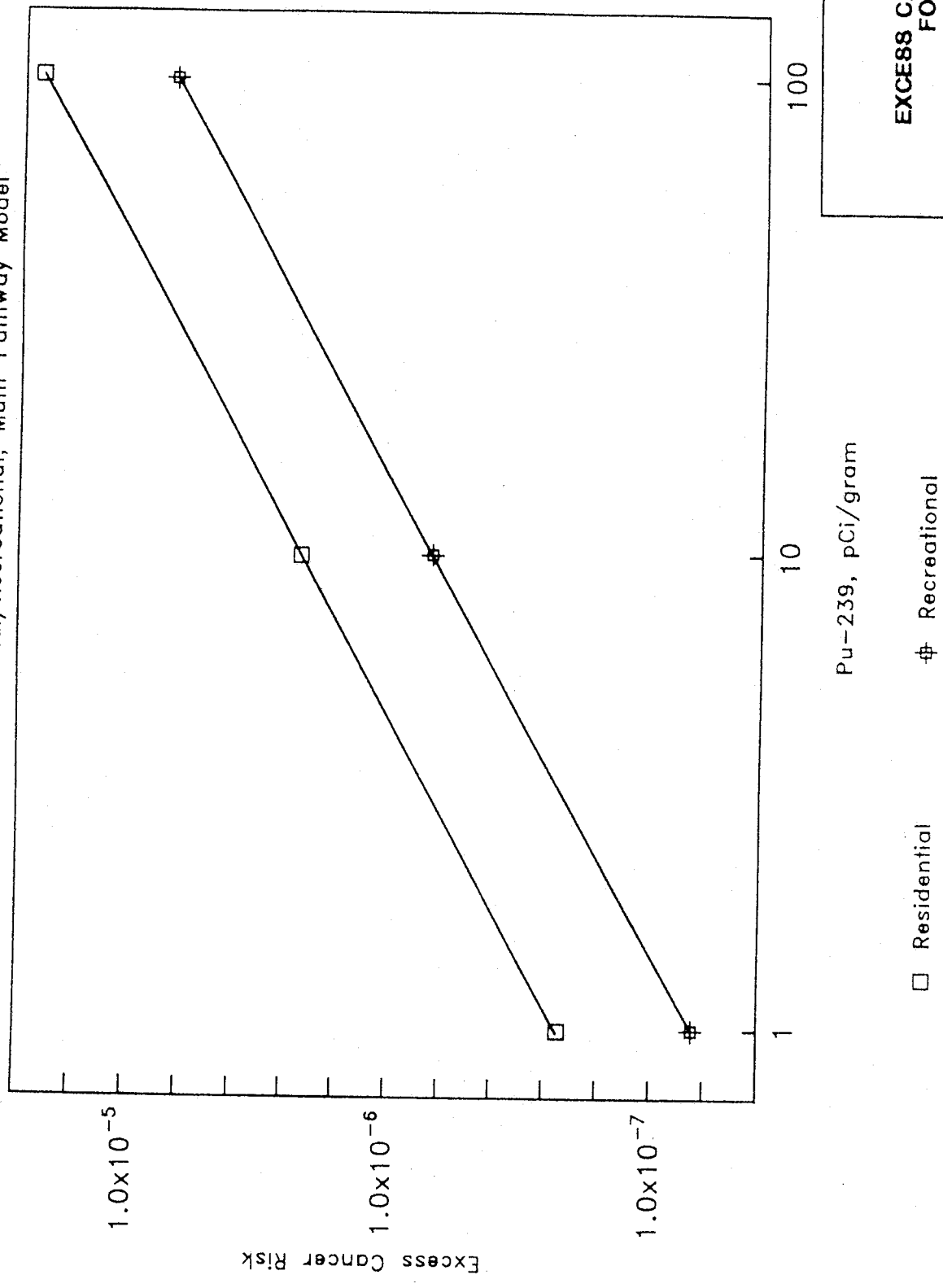
FIGURE C-1

EXCESS CANCER RISK FOR PU-239 IN SOILS

CONSERVATIVE MODEL